

AMENDMENTS TO THE CLAIMS:

This listing of claims will replace all prior versions, and listings, of claims in the application:

1. (Currently amended) A data processing apparatus for speeding-up execution of program instructions received from a main memory, comprising:

a main memory which stores program instructions and data;

a first instruction stream processor comprising a computing unit configured to perform computations based on one or more instructions obtained from an instruction region in main memory containing program instructions;

a register by which the first instruction stream processor writes and reads instruction data to/from the main memory, and

an input/output group generator, operatively functioning as an instruction sequence reuse window, that generates input/output (I/O) group data based on execution of a sequence of program instructions from the instruction region, said I/O group data having an input pattern comprising one or more instruction sequence input elements and an associated output pattern comprising one or more instruction sequence output elements; and

said data processing apparatus further comprising an instruction region storage section comprising content addressable memory (CAM) and random access memory (RAM) memory portions, operatively functioning as data reuse table, for storing I/O group data used for reusing certain sequences of instructions, wherein said instruction region storage section further includes an I/O group storage portion used to store the I/O group data, and wherein, at a time of executing one or more instructions read out from the instruction region in main memory, and upon identifying a matching pattern of instruction sequence input data found the instruction region

with an input pattern of I/O group data stored in the I/O group storage portion, the first stream processor performs a reuse operation that outputs the associated output pattern to the register and/or the main memory, and wherein

the input/output group generator also generates dependency relations information and includes a dependency relations storage memory section for storing dependency relations information, the dependency relations storage memory section comprising a two-dimensional (2D) matrix-arranged memory in which instruction sequence input elements are associated to particular columns of the memory and corresponding instruction sequence output elements are associated to particular rows of the memory, and each storage element within the 2D matrix-arranged memory contains dependency relations information indicative of whether a particular instruction sequence output element corresponding to a particular row of the memory is derived from or has some dependency relationship to a particular instruction sequence input element corresponding to a particular column of the memory, and wherein

the input/output group generator further includes an I/O group data setter which, based on information stored in the dependency relations storage memory, sets I/O group data that is made up of an output pattern that includes at least one of said instruction sequence output elements and an input pattern that includes at least one of said instruction sequence input elements.

2. (Previously presented) The data processing device as defined in claim 1, wherein if a first group of instruction sequence input elements, from which a first instruction sequence output element is derived, is included entirely within a second group of instruction sequence input elements, from which a second instruction sequence output element different from the first instruction sequence output element is derived, the I/O group data setter: (i) sets the second

group of instruction sequence input elements as the input pattern and (ii) sets the first group of instruction sequence input elements and the second group of instruction sequence input elements as the output pattern.

3. (Previously presented) The data processing device as defined in claim 1, wherein if there is no shared instruction sequence input element between a first group of instruction sequence input elements, from which a first instruction sequence output element is derived, and a second group of instruction sequence input elements, from which a second instruction sequence output element different from the first instruction sequence output element is derived, the I/O group data setter: (i) sets a first I/O group data in which the first group of instruction sequence input elements is the input pattern and the first instruction sequence output element is the output pattern and (ii) sets a second I/O group data in which the second group of instruction sequence input elements is the input pattern and the second instruction sequence output element is the output pattern.

Claim 4 (Canceled)

5. (Currently Amended) The data processing device as defined in claim [[4]] 1, wherein after a readout operation from the register and/or from an instruction region in the main memory is performed and upon said first instruction stream processor performing execution of one or more instructions obtained from the register or the instruction region, the input/output group generator further performs operations of:

(1) when an address of the register and/or the main memory from which the readout operation was performed is registered in the dependency relations storage memory section as an instruction sequence output element, creating a temporary provisional dependency relationship information storage matrix comprising rows and columns of memory elements within the dependency relations storage memory section, wherein a particular row is associated to that particular instruction sequence output element corresponding to the registered address;

(2) when an address of the register and/or the main memory from which the readout operation was performed is registered in the dependency relations storage memory section as an instruction sequence input element rather than an instruction sequence output element, creating a temporary provisional dependency relationship information storage matrix comprising rows and columns of memory elements within the dependency relations storage memory section, wherein a particular column of memory elements is associated to that particular instruction sequence input element corresponding to the registered address, and wherein a particular memory element in a column associated with the instruction sequence input element is set to a logical "1", and remaining memory elements in a same column are set to a logical "0"; and

(3) when an address of the register or the main memory from which the readout operation was performed is registered in the dependency relations storage section as neither an instruction sequence output element nor an instruction sequence input element, (i) registering the address and its value in the dependency relations storage section as instruction sequence input elements, and (ii) creating a temporary provisional dependency relationship information storage matrix comprising rows and columns of memory elements within the dependency relations storage memory section, wherein a particular column of memory elements is associated to that particular instruction sequence registered as input elements and a particular memory element in said

column is set to a logical "1", and remaining memory elements in that same column are set to a logical "0"; and

under a condition where a writing operation is performed to the register and/or the main memory, the I/O group data generator performs further operations of:

(4) when an address of the register and/or the main memory to which the writing operation is performed is registered as an instruction sequence output element, (iii) updating an instruction sequence output value corresponding to the registered instruction sequence output element to a value written by the writing operation, (iv) replacing a value stored in a row element of the temporary provisional dependency relationship information storage matrix within the dependency relations storage section, wherein said row element being replaced corresponds to a row associated to the registered instruction sequence output element, with a result of a logical OR-ing of all provisional matrices temporarily stored at that time, and then (v) initializing the temporarily-stored provisional matrices; and

(5) when an address of the register and/or the main memory ~~means~~ to which the writing operation is performed is not registered as an instruction sequence output element, (vi) registering the address and its value as an instruction sequence output element in the dependency relations storage memory section, (vii) replacing a value stored in a row element of the temporary provisional dependency relationship information storage matrix within the dependency relations storage section, wherein said row element being replaced corresponds to a row associated to that instruction sequence output element, with a result of a logical OR-ing of all provisional matrices temporarily stored at that time, and then (viii) initializing the temporarily-stored provisional matrices.

6. (Currently amended) The data processing device as defined in claim [[4]] 1, wherein, the I/O group data pattern setter includes a logical operation computation section which performs a logical “AND” operation of the row elements in the 2D matrix-arranged memory, and (i) extracts a group of row elements for which a logical AND operation of an inversion of a first row element and a second row element are each a logical “0”, and (ii) among the extracted group of the row elements, excludes, as a candidate for an input/output group, row elements other than a row element that includes a largest number of the input elements.

7. (Currently amended) The data processing device as defined in claim [[4]] 1, wherein, the I/O group data pattern setter includes a logical operation computation section which performs a logical “AND” operation of the row elements in the 2D matrix-arranged memory, and sets, as an input/output group, a row element whose logical “AND” operation with any other row elements are all logical “0”.

8. (Previously presented) The data processing device as defined in claim 1, further comprising a second instruction stream processor having a second computing unit configured to perform computations on instructions from an instruction region in main memory, wherein with respect to instructions in the instruction region processed by the first computing unit, the second computing unit subjects instructions from the instruction region to a computation based on a predicted input value, and registers a result of the computation in the instruction region storage section.

9. (Currently amended) The data processing device as defined in claim 1, wherein,

the I/O group data pattern setter further comprises:

an output-side group storage section which stores information of an input/output group to which each of the output elements belongs;

an input-side group storage section which stores information of an input/output group to which each of the input elements belongs;

a temporal storage section which stores [[a]] an indication of a changed dependency relation between an output element and an input element whenever there is a change in information stored in the dependency relations storage section when I/O group data is generated; and

a group temporal storage section which stores information of changed I/O group data when there is a change in information stored in the dependency relations storage memory section when the input/output group is generated.

10. (Previously presented) The data processing device as defined in claim 9, wherein the I/O group data pattern setter further includes a group management section that stores information of the I/O group data which has previously been allocated to an output element and/or an input element when the input/output group is generated.

Claim 11 (Canceled)

12. (Previously presented) The data processing device as defined in claim 10, wherein the temporal storage section stores results of a logical OR-ing of memory elements of a plurality of rows in the dependency relations storage section, and

the group temporal storage section stores: (i) the result of a logical OR-ing of memory elements of a plurality of rows in the output side group storage section and/or (ii) the result of a logical OR-ing of memory elements corresponding to a plurality of input elements in the input side group storage section.

13. (Previously presented) The data processing device as defined in claim 9, wherein the I/O group data pattern setter further includes a conditional branch storage section that stores information regarding an input element on which the conditional branch instruction depends whenever a conditional branch instruction is detected when the I/O group data is generated.

14. (Previously presented) The data processing device as defined in claim 12, wherein, under a condition where a readout operation from the register and/or the main memory is carried out while the first stream processor performs a calculation of the input region, the input/output group generator further performs operations of:

(1) when an address of the register and/or the main memory from which the readout operation was performed has been registered as an output element in the dependency relations storage memory section, temporarily storing, in the temporal storage section, a logical OR of (i) a row element of the dependency relations storage memory section, wherein said row element corresponds to the output element, and (ii) elements in the temporal storage section, and storing, in the group temporal storage section, a logical OR of (iii) a row element of the output side group storage section, wherein said row element corresponds to the output element and (iv) elements in the group temporal storage section;

(2) when an address of the register and/or the main memory from which the readout operation was performed is registered as an input element rather than an output element in the dependency relations storage memory section, storing in the temporal storage section information in which a memory element corresponding to a column of the dependency relations storage section, wherein said column corresponds to the input element and is set to a logical "1" and remaining memory elements are set to a logical "0", and storing in the group temporal storage section a logical "OR" of: (v) elements, from the input-side group storage section that correspond to the input element and (vi) the elements in the group temporal storage section; and

(3) when an address of the register and/or the main memory from which the readout operation was performed is not registered in the dependency relations storage memory section as either an output element or an input element, registering as input elements, the address and its value in the dependency relations storage section, and temporarily storing a provisional matrix in which a memory element corresponding to a column, of the dependency relations storage section, which corresponds to the input element is set to a logical "1" while remaining memory elements are set to a logical "0", and

under a condition where writing is carried out to the register and/or the main memory, the input/output group generator performs further operations of:

(4) when an address of the register and/or the main memory to which the writing performed is registered as an output element, updating an output value corresponding to the registered output element to the written value, replacing a row element of the dependency relations storage memory section wherein said row element corresponds to the registered output element, with the information temporarily stored in the temporal storage section at the time, and (viii) updating the information in the output side group storage section, which information

corresponds to the output element, and (ix) updating the information in the input side group storage section, which information corresponds to the input elements on which the output element depends, based on the information stored in the group temporal storage section; and

(5) when an address of the register and/or the main memory to which the writing is carried out is not registered as an output element, registering the address and its value as output element in the dependency relations storage memory section, and replacing a row element of the dependency relations storage section, wherein said row element corresponds to the output element, with the information temporarily stored in the temporal storage section at that time, and (x) updating the information in the output-side group storage section, wherein said information corresponds to the output element, and (xi) updating the information in the input side group storage section, wherein said information corresponds to the input elements on which the output element depends, based on the information stored in the group temporal storage section.

15. (Previously presented) The data processing device as defined in claim 1, wherein the instruction region storage section includes an instruction sequence input pattern storage section which stores instruction sequence input patterns as a tree structure in which items which should be subjected to equal comparison are regarded as nodes.

16. (Previously presented) The data processing device as defined in claim 15, wherein the input pattern storage section is configured to organize and store the tree structure in such a manner that a value of an item in the input pattern, which item is subjected to equal comparison, is stored in association with an item which is to be next subjected to a comparison.

17. (Previously presented) The data processing device as defined in claim 16, wherein the input pattern storage section further includes associative search performing circuitry and an additional information storage section, wherein the associative search performing circuitry utilizes one or more search target lines that include a value storage portion in which a value of an item to be subjected to equal comparison is placed, and a key storage portion in which a key for identifying each item is placed; and the additional information storage section includes a search item designation area in which an item to be next subjected to an associative search is stored in accordance with a search target line.

18. (Withdrawn) A data processing device which reads out an instruction region from main memory means and writes a result of a computation into the main memory means, the data processing device comprising:
first computing means for performing a computation based on the instruction region read out from the main memory means;
a register by which the first computing means reads out or writes data to/from the main memory means; and
input/output pattern storage means for storing an input pattern and an output pattern which are a result of execution of a plurality of instruction regions,
in a case where the first computing means executes an instruction region and an input pattern of the instruction region is matched with an input pattern stored in the input/output storage means, a reuse process is performed so that an output pattern, which is stored in the

input/output storage means in association with the input pattern, is outputted to the register and/or the main memory means,

the data processing device further comprising:

registration processing means for (i) distinguishing, among the input elements in the input pattern, an input element to be subjected to prediction from an input element not requiring prediction, at the time of storing, in the input/output storage means, a result of execution of the instruction region by the first computing means, and (ii) registering, in the input/output storage means, information regarding the distinction;

prediction processing means for predicting a variation of a value of the input element to be subjected to prediction among the input elements stored in the input/output storage means, based on the information regarding the distinction; and

second computing means for subjecting the instruction region to precomputation, based on the input element predicted by the prediction processing means,

a result of the precomputation of the instruction region by the second computing means being stored in the input/output storage means.

19. (Withdrawn) The data processing device as defined in claim 18, wherein,

in a case where (i) an address of the register used for input is used as a stack pointer or a frame pointer or (ii) a writing instruction to the address is a constant setting instruction, the registration processing means sets a constant flag in the address, as the information for the distinction, while in a case where neither (i) or (ii) holds true, the registration processing means resets a constant flag of the address.

20. (Withdrawn) The data processing device as defined in claim 18, wherein,

in a case where an input element is newly stored in the input/output storage means, the registration processing means resets, as the information for the distinction, a change flag in an address of the input element, while, in a case where, after the input element is stored in the input/output storage means, a storing instruction is executed with respect to the address, the registration processing means sets a change flag in the address.

21. (Withdrawn) The data processing device as defined in claim 19, wherein,

in a case where an input element is newly stored in the input/output storage means, the registration processing means resets, as the information for the distinction, a history flag in an address of the input element, while, in a case where, at the time of execution of a load instruction with respect to the address, the constant flag is set in a register address from which the address is generated, the registration processing means sets a history flag in the address.

22. (Withdrawn) The data processing device as defined in claim 21, wherein,

in a case where an input element is newly stored in the input/output storage means, the registration processing means resets, as the information for the distinction, a flag of an address of the input element, while, after the input element is stored in the input/output storage means, a storing instruction is executed with respect to the address, the registration processing means sets a change flag in the address, and

the prediction processing means performs prediction of a variation of an input element, as to an address in which the change flag and the history flag are set, among addresses of the input elements stored in the input/output storage means.

23. (Withdrawn) The data processing device as defined in claim 18, wherein,
the prediction processing means performs prediction of a variation of an input element,
only as to an input element in which a variation of a value of the input element in the history is
not 0, among the input elements stored in the input/output storage means.

24. (Withdrawn) The data processing device as defined in claim 18, wherein,
when the result of execution of the instruction region by the first computing means is
stored in the input/output storage means, the registration processing means (i) distinguishes,
among the input elements in the input pattern, an input element to be subjected to prediction
from an input element not requiring prediction, (ii) registers information regarding the distinction
in the input/output storage means, (iii) counts how many times storing is carried out at the time
of execution of the instruction region, as to the output elements of the output pattern stored in the
input/output storage means, and (iv) store the counted value in the input/output storage means,
and

the second computing means (i) subjects the instruction region to precomputation, based
on the input element having been predicted by the prediction processing means, and (ii) performs
the precomputation of the instruction region by waiting for a time corresponding to the number
of times of storing performed with respect to the input element based on the counted value, and
then performing readout from the main memory.

25. (Withdrawn) The data processing device as defined in claim 24, wherein,

the input/output storage means includes an input/output storage area which temporarily stores an input pattern and an output pattern which are the result of execution of the instruction region by the first computing means, and

the input/output storage area includes a store counter which counts how many times the storing is carried out with respect to each of the output elements.

26. (Withdrawn) The data processing device as defined in claim 25, wherein,
the input/output storage means includes a history storage area which stores a history of a past result of execution of each instruction region subjected to computation by the first computing means, and

the registration processing means (i) stores, in the history storage area, the result of execution which is stored in the input/output storage area, and (ii) with respect to an input element having an address identical with an address of an output element which is stored, in the history storage area, as a result of execution of the last time, registers a store counter of a corresponding directly-preceding output element, as a store counter of the input element.

27. (Withdrawn) The data processing device as defined in claim 26, wherein,
the input/output storage means includes a predicted value storage area which stores an input element predicted by the prediction processing means, and

the prediction processing means subjects, to prediction, an input element whose value consistently varies between execution histories, among the input elements stored in the history storage area, and stores a result of the prediction in the predicted value storage area.

28. (Withdrawn) The data processing device as defined in claim 26, wherein,
the input/output storage means includes a waiting-required address storage area which stores an input element that should be read out from the main memory after waiting for a time corresponding to the number of times of the storing, and
with respect to an input element whose address in an execution histories does not change and whose variation of a value between the execution histories is inconsistent, the prediction processing means stores, in the waiting-required address storage area, the store counter and a waiting counter as a value based on a predicted distance.

29. (Withdrawn) The data processing device as defined in claim 26, wherein,
the input/output storage means includes a waiting-required address storage area which stores an input element that should be read out from the main memory after waiting for a time corresponding to the number of times of the storing, and
with respect to an input element whose address changes between execution histories and values of changed addresses change on account of the storing, among the input elements stored in the history storage area, the prediction processing means stores, in the waiting-required address storage area, a waiting counter as a value based on the store counter.

Claims 30-32 (Canceled)